GUIDELINES FOR TURKEY PROCESSING PLANT LAYOUT

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By W. L. SHUPE, *research mechanical engineer,* and E.W. SPANGLER, *engineering technician (retired), Agricultural Research Service (ARS), Western Region, University of California, Davis;* JOHN A. HAMANN, *Chief (retired), Dairy and Poultry Products Marketing Labaratory, Agricultural Marketing Research Institute, ARS, Beltsville, Md.;* and A.WADE BRANT, *food technologist, University of California, Davis*

SUMMARY

An efficient layout of a basic plant for processing whole, ready-to-cook turkeys and provision for further processing is developed and described in this report. The intent is to assist plant operators with layout and design features for completely new plants as well as additions to, and renovation of, existing facilities when production rates are increased and new products are processed. Step-by-step additions to the basic plant (slaughter and evisceration operations) include fast freezing, frozen storage, and further processing of the whole carcass into convenience items. This layout provides for efficient product flow throughout the entire operation without interfering with production or necessitating major changes in any completed section of the plant if and when the additions are made.

Planned production rates for this plant layout vary from 150,000 pounds of turkey products per day, using a single eviscerating line, up to 300,000 lb/day when a double line is used. For good manageability, a plant layout design should provide for expansion and product diversification. The major guidelines taken into account in preparing the plant layout include the following: (1) Where a specific operation is performed, each area is arranged to permit efficient operation and a direct flow of the product; (2) in the overall plant layout, each area is connected in sequence to allow smooth flow of products and materials through the entire plant; and (3) provisions for meeting regulatory requirements include (a) product wholesomeness, (b) personnel health and safety, (c) employee comfort and convenience, and (d) plant maintenance.

BACKGROUND

Turkeys are a seasonal crop. A large percentage of the annual crop is slaughtered from early fall through the holiday season. In the past, these birds were marketed as whole turkeys only — first as New York-dressed, later as ready-to-cook (eviscerated) birds. If these were not all sold during the holiday season, the balance was held in commercial cold storage plants until they were marketed as whole birds. In the early days, processing plants were designed for processing New York-dressed turkeys and generally shut down when the marketing season was over. The season generally lasted from September to January. Freezing and low temperature storage facilities were provided by commercial cold storage houses.

With the advent of plants converting to ready-to-cook operations and U. S. Department of Agriculture (USDA) inspection for wholesomeness, it became possible to further process turkeys into specialty items at times when the plants would normally have been shut down. By further processing whole, ready-to-cook turkeys into convenience items — such as turkey parts, boned turkey meat, rolled roasts, frozen dinners, and pot pies — many turkey processing plants have become year-round operations. These modern methods of marketing turkeys have changed the plant from the early day slaughterhouse into a modern food processing facility. In accomplishing this complex step, turkey processors greatly increased their investment in facilities and equipment. In many cases, alterations and additions were made to existing structures. This usually required a plant shutdown during alteration, which, under today's operating conditions, is inconvenient and costly. Unfortunately, the layouts that resulted, in many cases, were inefficient.

Much progress has been made by processors, researchers, and equipment manufacturers in improving methods and equipment used in the

industry. Compliance as to product wholesomeness and facility acceptability is now required under the terms of the Poultry Products Inspection Act of 1957 *(11)*,[1] the Williams-Steiger Occupational Safety and Health Act of 1970 *(9)*, and the Federal Water Pollution Control Act as amended in 1972 *(8)*. When planning new structures or remodeling existing facilities, plant management has to meet the requirements set by these laws while developing an efficient layout for processing operations. The intent of this report is to assist plant operators with layout and design features for completely new plants as well as additions to, and renovation of, existing facilities when production rates are increased and new products are processed.

This information is based on studies made at a number of turkey processing plants in the Western United States and supplemented with research data from earlier work reported in publications by the Agricultural Research Service, Agricultural Marketing Service, and Animal and Plant Health Inspection Service *(2, 7, 10, 12, 13)*.

SYSTEMATIC LAYOUT PLANNING

The basic factors to consider when planning an efficient industrial food processing plant layout *(4, 5, 6)* are: (1) Nature of the raw materials and finished products; (2) production rate for each product; (3) number of work stations and area required for each operation; (4) location of specific work areas in relation to one another; and (5) structural design required for economic future expansion with minimal disruption of operations.

In addition to these considerations, location of facilities auxiliary to the production operation, such as management offices and personnel amenities, should be conveniently located. These areas would include office space, restroom and toilet facilities, and a lunchroom, which can be planned for convenience without interfering with plant operations.

To convert live turkeys into whole, ready-to-cook carcasses, the live birds are hung on a shackle and moved through the entire process on overhead monorail conveyors in an assembly line type of operation. The first step in the operation is to place the live bird on the conveyor at the receiving dock. The steps that follow in sequence are slaughter, scald, defeather, and wash. The defeathered and washed carcass is then transferred to the overhead eviscerating conveyor that carries the bird through the eviscerating area in the process of converting it into the whole body, ready-to-cook form. It is then chilled. This is frequently done in an inline-type chiller that submerges the bird in water and crushed ice as it is moved forward and emerges ready for draining, wrapping, or further processing.

In establishing the most desirable production rate for the plant, the most complex processing operation value is used for a base. In a turkey processing plant, more than 50 percent of the lineworkers are involved with the eviscerating operation. The optimum rate at which this operation can be accomplished, as well as the rate at which the USDA inspector can adequately inspect *(11)*, controls the production rate. A production rate of 300,000 pounds of dressed turkey per day was selected for this report, based on recent research *(7)* with optimum worker utilization. Figure 1 shows the relationship of one activity area to another and of the space requirements for each in a turkey processing plant of this production rate. The diagram also shows product and packaging materials flow lines, which are very important and must be given considerable attention when planning the overall layout for an efficient operation. Auxiliary or service areas are also shown in this diagram and must be considered in the final plant layout.

The use of scaled templates and a layout board are useful tools in planning a layout. This method offers the designers a chance to try many changes in arriving at the most efficient layouts without making time-consuming changes in drawings. Turkey processors who start with the preparation of whole, ready-to-cook, chilled birds and change over to more complex operations by adding freezing, cold storage, and further processing facilities will benefit by this approach.

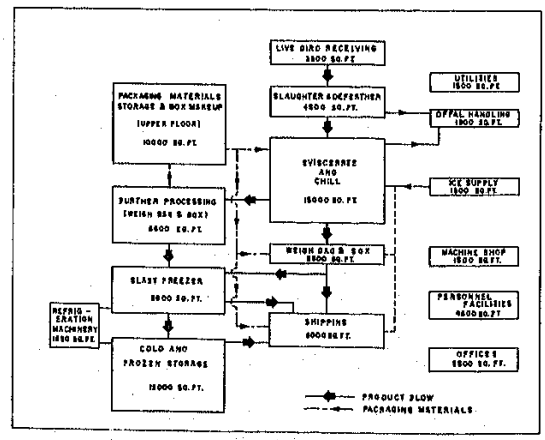

FIGURE 1.—Space relationship flow diagram.

[1] Italic numbers in parentheses refer to Literature Cited, p. 22.

THE FACILITY LAYOUT

The basic plant layout shown in figure 2 illustrates the location and space requirements of the various areas for a plant processing 300,000 pounds of whole, ready-to-cook turkey daily with provisions for step-by-step additions to handle rapid freezing, frozen and cold storage, and further processing. The first addition is the blast freezer.[2] Its capacity is 300,000 pounds, or one day's production. The next addition is the cold (35° F) and frozen (0°) storage areas. A capacity of 3 million pounds, which is 10 days' production, was chosen arbitrarily. Marketing conditions cause the storage capacity to vary greatly from place to place.

The further processing area is the third addition planned. Further processed turkey products are quite numerous and require a large assortment of packaging materials, necessitating additional dry materials storage space. This storage space is provided on the second floor over the blast freezer addition (fig. 3).

A receiving dock for plant supplies and packaging materials is included in the third addition. This eliminates crowding and confusion in the product shipping area when further processed products are produced.

The basic layout was developed with the fundamentals of systematic planning in mind. It consists of major activity areas for live bird receiving, slaughtering and defeathering, eviscerating, chilling, packaging, and shipping whole, ready-to-cook birds. The auxiliary or service areas —such as live bird truck washing, boiler room, utilities room, offal handling, ice manufacturing and storage, offices, personnel facilities, and packaging materials storage and makeup (fig. 1)—have been placed in locations that permit a smooth product flow through the facility. The three additions, blast freezing, frozen storage, and further processing (fig. 2), can be brought about without costly renovations to existing areas of operation or disruption of production. Thus, with minimal congestion, bottlenecks, and cross traffic, live bird trucks unload at one side of the plant, supplies and packaging materials are received on the other, offal trucks are loaded at the rear, and the product is loaded at the front next to the office.

For a smaller operation with a daily production rate of 150,000 pounds, the basic plant for processing whole, ready-to-cook chilled birds can be operated with a single eviscerating line and correspondingly less slaughtering, scalding, and defeathering capacity. Structural dimensions of the basic plant should not be reduced for this lower production rate because relocating major equipment in these areas when production is increased would be very costly and time consuming. The three additions can vary in dimensions best suited to the needs established by area and marketing requirements.

LIVE BIRD RECEIVING AREA

In the case-study plants observed in this research, birds were transported to the processing plant in vans in battery-type cages permanently attached to the vehicle. When the van first arrives at the plant, it is weighed and then moves to the unloading area (fig. 4), where adjustable height conveyors and worker platforms provide easy reach for workers while hanging birds in shackles (fig. 5). An electric hoist and cable system can position either side independently, allowing for variations in work rates. Another method of doing this can be accomplished by means of a hydraulic hoist (fig. 6). The hoist raises the van to the desired height to permit workers on raised platforms a convenient reach into each compartment level. The dock is wide enough to provide for a walkway and permits unloading from both sides of the truck. In addition, the dock is long enough to accommodate double trailers in areas where doubles are used.

A van-washing area is provided for cleaning after unloading. The whole dock area should be covered to provide shelter for workers, birds, and equipment during inclement weather. Suction fans are suggested for use over the center of the dock area for ventilation and picking up the loose feathers.

In the area between unloading birds from the truck and dispatching birds, a clear area for USDA ante mortem inspection and necessary facilities must be provided. A small office and restroom for truckdrivers, receiving clerk, and other workers in this area of the plant, have been provided in the office and personnel facilities section of the plant (see p. 13).

[2]Initially, access is through a temporary doorway (not shown) in the shipping dock wall. After the second addition is completed, the door opening is moved to the cold storage room wall, and access to the freezer is through a door from the freezer to the cooler, establishing a vestibule effect for the freezer.

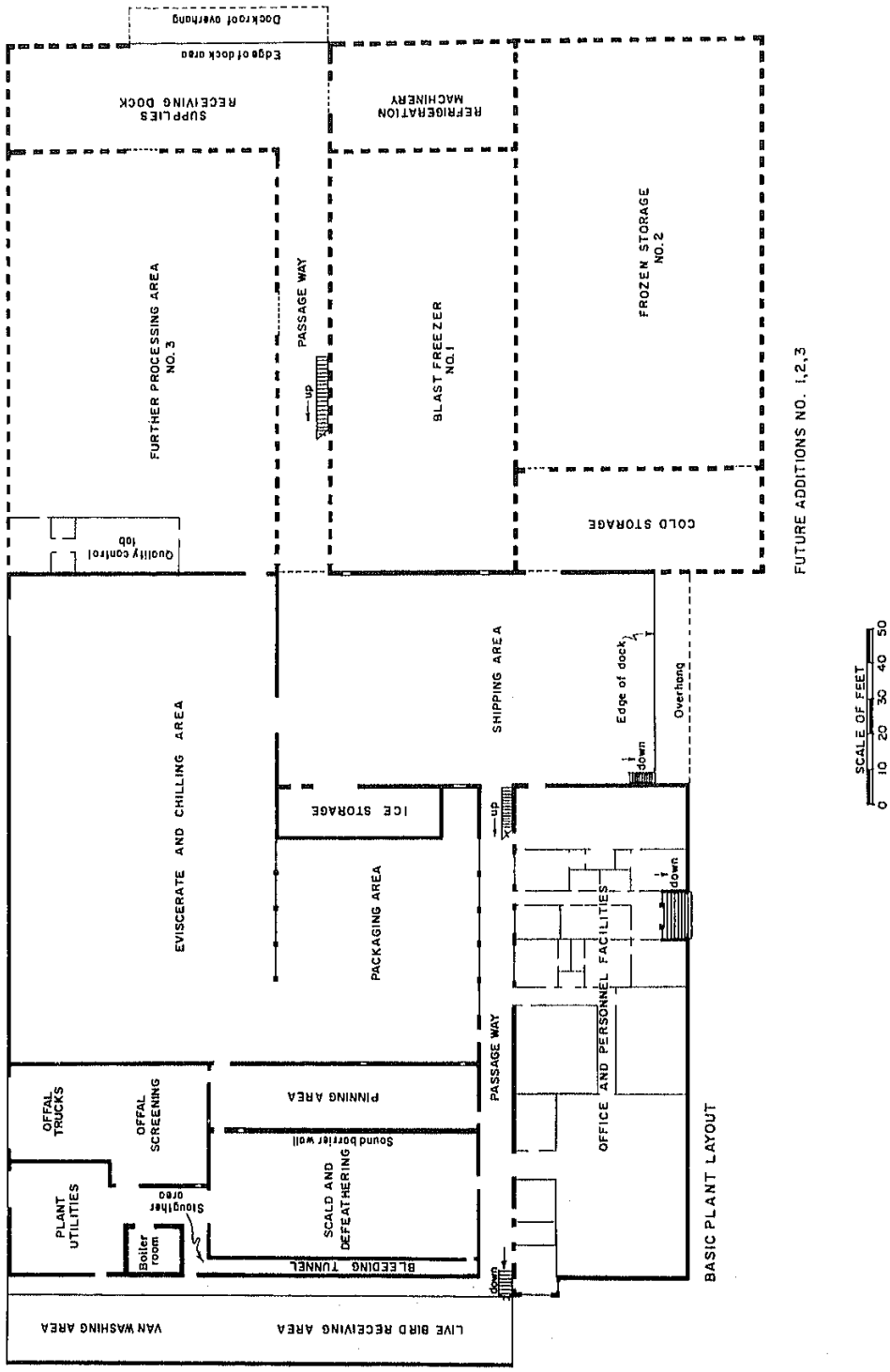

FIGURE 2.—Basic plant layout for turkey processing plant and three additions for expansion.

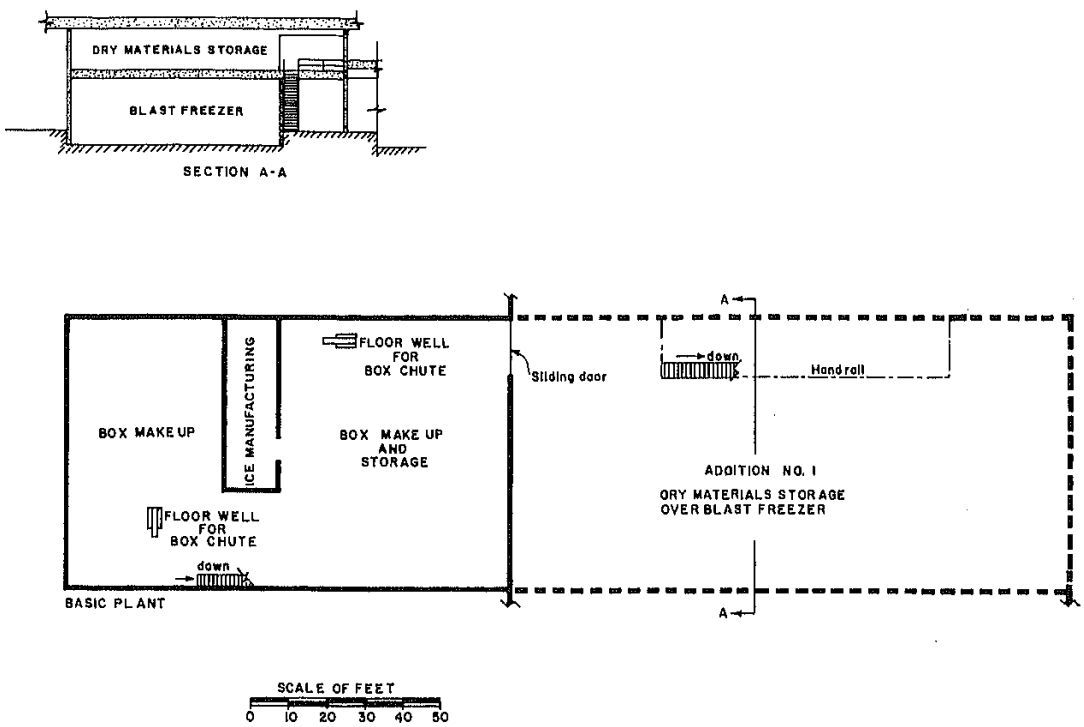

FIGURE 3.—Second floor layout and section view of part of basic plant and additions.

SLAUGHTERING AREA

Birds enter the blood tunnel (fig. 4) on the overhead conveyor, hanging by their feet. It is important to allow enough width (6 feet) in this tunnel to prevent bruising by birds flapping against walls. The blood tunnel should be of sufficient length to allow ample bleeding time before scalding. The actual length depends on line speed and the estimated time required for adequate bleeding. USDA regulations require that blood from the slaughter operation be confined effectively. Since most local regulations prohibit dumping blood into sewerlines, it is generally disposed of after coagulation. Two methods of doing this are used: (1) Coagulated blood is swept into a collection gutter and moved to the offal room by auger, or (2) a vacuum system, similar to that used for lung removal, is used periodically to suck coagulated blood from the gutter to the offal room.

The ceiling, floor, and walls of the slaughter area and blood tunnel must be washed down regularly, necessitating the use of a glazed surface that is impervious to moisture. Hot and cold water outlets and steam must be provided at convenient locations for cleanup of the area. A space heater should be provided for the area to provide worker comfort in cold weather. Lighting equal to 30 footcandles (fc) at the slaughtering station and 10 fc in the blood tunnel is suggested as sufficient. Fans should be provided for adequate ventilation for personnel in the tunnel and at the slaughtering station.

SCALDING AND DEFEATHERING

Scalding Area

As the birds leave the blood tunnel, they enter the scald tank. The dimensions of this tank are controlled by the line speed and time required for loosening the feathers. The conveyor line can be constructed so as to make one or more passes through the tank. One pass requires a long, narrow tank, whereas two passes would reduce the length, but add to the width. The dimensions of the space available for this purpose would be the deciding factor as to the number of passes birds make through the tank. Tanks are manufactured in sections allowing for this dimensional variation. The floor in this area must be provided with

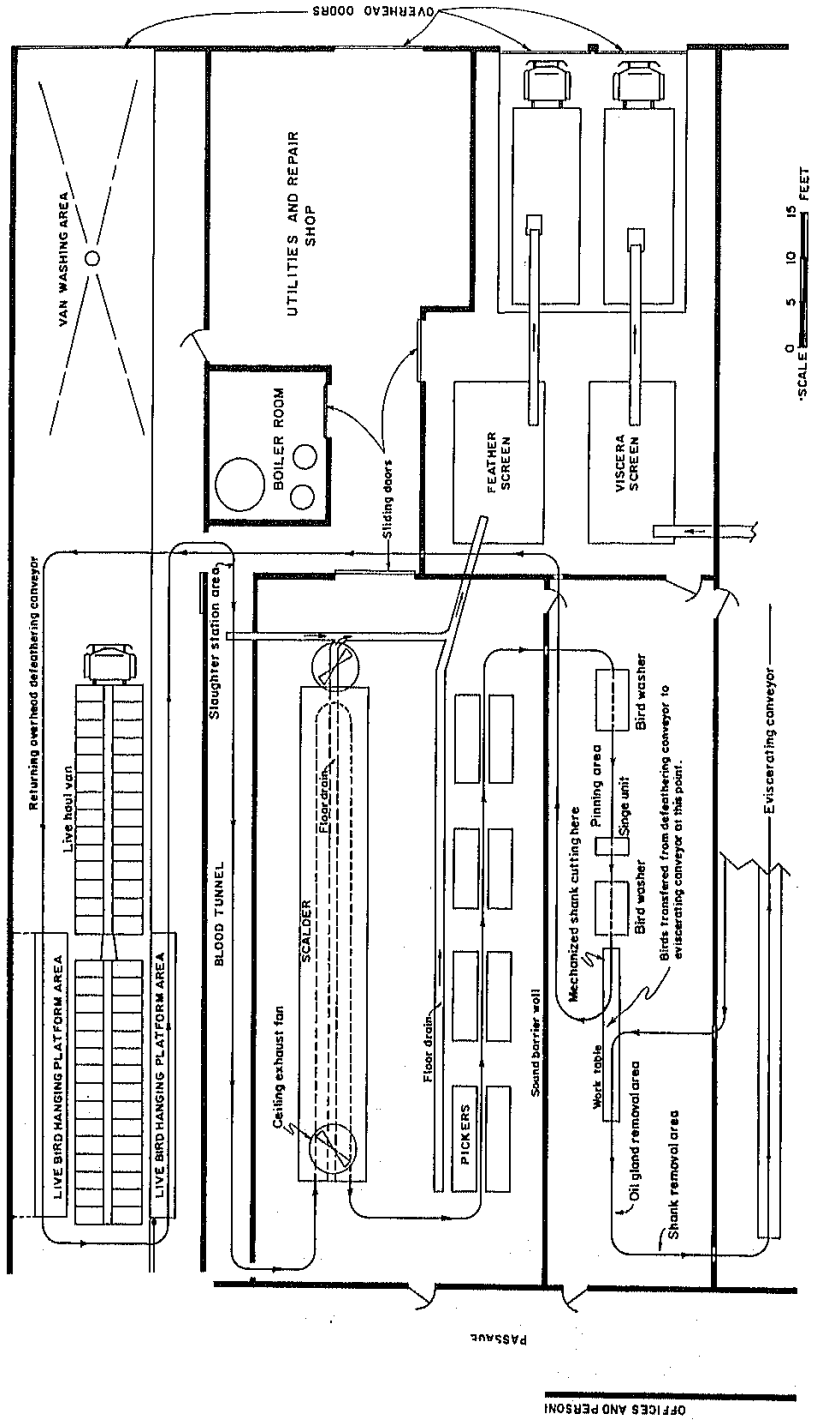

FIGURE 4.—Equipment layout for live bird receiving, slaughtering, and defeathering areas.

proper drains to take care of overflow and cleanup. The scald tank itself must be connected to the processing waste sewer system for emptying and cleaning.

Good ventilation is essential to take care of moisture and heat buildup. Ventilation can be accomplished using air drawn from the eviscerating and food processing areas. This train of air would be of sufficient pressure to ensure flow from the picking area to the live handling dock, thus preventing entrance of feathers and dust-ladened air. Air should be forced through this section of the plant at a rate of at least one complete change per minute. Steam, water, and power outlets should be well located. Lighting equal to 25 fc is adequate for the area.

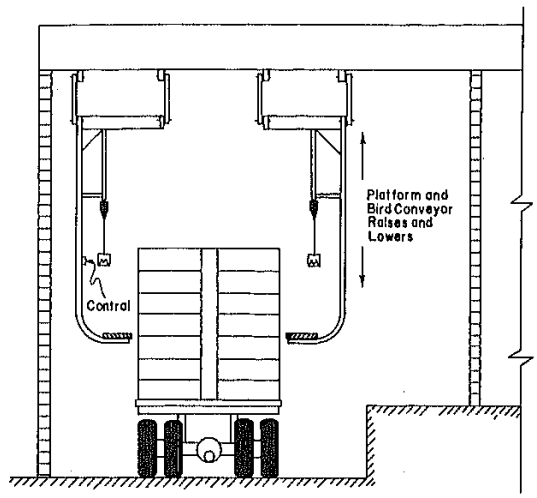

FIGURE 5.—Cross section of live bird receiving area with adjustable-height worker platform and bird conveyor.

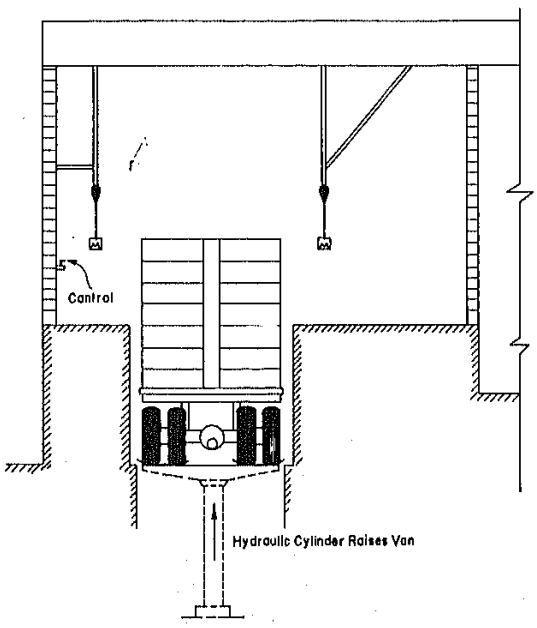

FIGURE 6.—Cross section of live bird receiving area with hydraulic hoist to adjust height of van.

To prevent overscalding birds during an unexpected line shutdown, provisions must he made for lifting the entire conveyor line of birds out of the scald water. Commercial equipment is available for this purpose.

Defeathering Area

The number of defeathering machines depends on the type used and the production rate desired. In planning the layout for a new plant, ample space should be provided for installing additional machines at a later date. The defeathering area, in most case-study plants, was found to be inadequate, making it costly to install new equipment and to maintain existing machines.

A gutter drain parallel to, and to one side of each row of machines, is required. The floor should slope with positive drainage toward the gutter. Provisions should be made for anchoring the picking machines securely because their efficiency depends on accurate alinement with the conveyor line.

Recently developed, completely enclosed scalding and picking equipment using steam, or hot water spray for scalding, or both should be considered for use in this area of operations. This equipment is quite versatile and can be installed in the space provided, taking the place of the scald tank and picking machines as shown in figure 4.

Also in figure 4, a sound barrier wall is shown between the mechanical pickers and the finishing and transfer stations. This wall would provide noise attenuation to protect workers from the excessively high levels generated by picking equipment currently available. The buffer room provided by this wall and the eviscerating area wall can provide an area for performing operations not normally allowed in the picking room.

Space must be provided for workers who remove pin feathers after the birds leave the picking machines. A bird singer is provided for the removal of vestigial feathers (hair) after which the birds are thoroughly washed before being transferred to the eviscerating line. Shanks and preen glands should he removed outside the defeathering room. This is usually done after birds are transferred to the eviscerating line at a point where the eviscerating line conveyor passes through the pinning area. If mechanized shank cutting is used, the machine is installed on the defeathering line. The carcass drops to a transfer

belt as the shanks are cut. The shanks continue on and are mechanically released from the shackle at any desirable locations as the shackle returns to the live bird hanging area. The pinning operation requires close inspection necessitating good lighting. A minimum of 50 fc of light is required for this area. As in other areas, hot water and steam outlets must be provided for cleanup operations.

OFFAL ROOM

Approximately 20 percent of the live weight of turkeys processed is discarded as inedible material in the form of blood, feathers, viscera, feet, heads, condemned carcasses, and parts. A plant processing 37,000 pounds of eviscerated turkeys per hour accumulates about 7,500 pounds of offal each hour. Facilities must be provided for rapid removal of this waste to prevent creating a nuisance and contaminating edible products.

The offal room should be located adjacent to the defeathering and the eviscerating areas. This allows a minimum distance for moving feathers and offal to the offal room. All gutters must be large enough to handle the necessary volume of water[3] and waste and sloped for effective movement of waste product. Feather gutters require less slope than offal gutters from the eviscerating area; 1-inch slope per 50 feet for feathers and 1-inch slope per 19 feet for viscera are recommended. Blood from the blood tunnel is usually combined with the feathers for disposal. Feather disposal gutters and viscera disposal gutters empty into different mechanical separators in the offal room, where the solids are separated from the water. Feathers and other offal are then conveyed to separate, waiting trucks. As a water-conserving measure, some of the water from the separators can be recirculated to assist in feather flowaway. The truck-loading area should be sloped to trapped drains for carrying off seepage and washdown water.

Two pits with floors dropped 3 to 4 feet, one for feathers and one for other offal, are provided in the offal room. This allows for sloping floor gutter drains and for installing separators and pumps. The floors should be sloped toward the pits, and the walls should be of moisture-impervious material, as frequent washdown is required for sanitation.

EVISCERATING AND CHILLING

In plants preparing only whole, ready-to-cook turkeys, 50 percent or more of the plant workers work in the eviscerating area. Therefore, particular attention should be given to the design and layout of work stations, aisle space, noise level, ventilation, and proper placement of personnel facilities. Figure 7 shows an efficient layout for this area.

The eviscerated carcasses are chilled promptly after evisceration. Plants with further processing operations do not truss[4] birds that are to be cut up. This requires that birds to be cut up be separated from the trussed birds before chilling. Figure 8 is a product flow chart, which identifies operations from eviscerating through shipping and shows the alternate routes the product may take before reaching the shipping dock.

Eviscerating Area

The main equipment item in this area, is the bird single or dual conveyor line, over a water-flushed offal trough. (Dry removal of offal[5] may take the place of the water-flushed trough without changing the layout, as shown in fig. 7.) Hand-wash nozzels are required at each 3-foot-long work station along the line. Foot or hip pedal-operated, self-closing-type valves are recommended on hand-wash nozzles as a means of conserving water.

The overhead monorail conveyor height should be located so that the birds reach the tallest workers at approximately their elbow height. Adjustable platforms can be used to elevate shorter workers to the same height. Conveyor line wear can be decreased and maintenance costs reduced if horizontal and vertical curves are held to a minimum.

The line should be long enough to provide 3-foot-long work stations for each worker and 8 feet for inspection (including room for trimmers), plus additional space for training new workers. The offal trough should be wide enough to accommodate the dual line even though a single line is first contemplated. In case of expansion, relocating or installing new equipment is expensive and necessitates a long period of shutdown.

Adequate aisle space is essential for personnel

[3]Research is now underway to reduce water-use rates by providing vacuum pickup of all offal and feathers.

[4]Whole, ready-to-cook birds are generally trussed.

[5]See footnote 3.

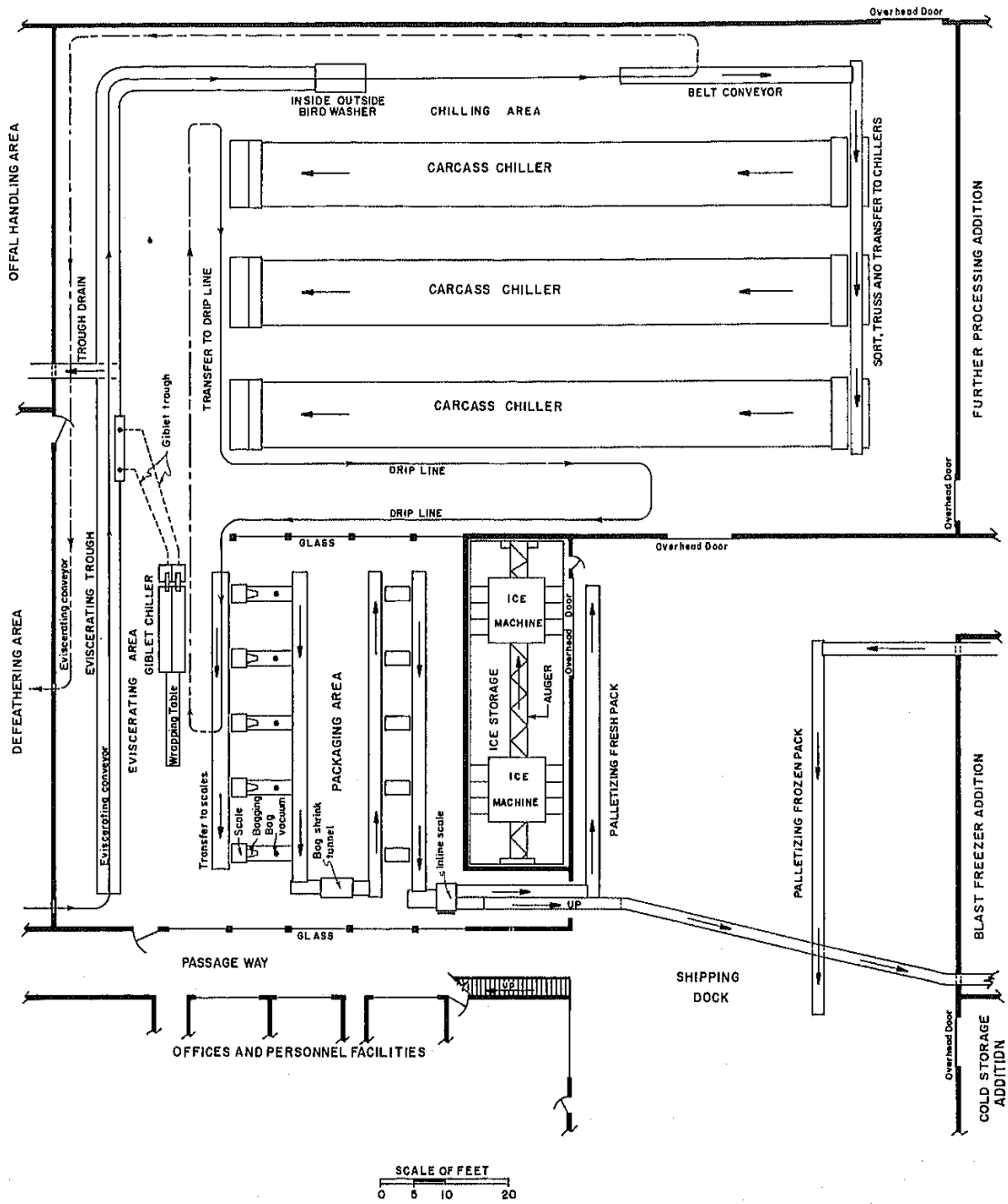

FIGURE 7.—Equipment layout for eviscerating, chilling, and packaging areas.

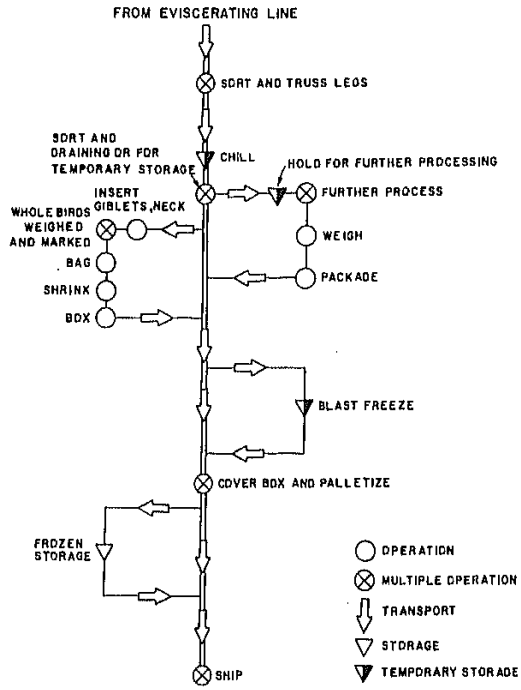

FIGURE 8.—Product flow chart of eviscerating through shipping operations.

safety and for minimizing damage to walls and fixed equipment by materials handling equipment. Unobstructed aisles 6 feet wide on each side of the eviscerating line, excluding space for workers, is ample. A guardrail between the line worker and the aisle space is recommended.

Electrical, air, and vacuum outlets must be provided where needed plus water and steam outlets for cleanup. Lighting should be at least 40 fc. Regulations call for 50 fc of light at inspection stations.

Ventilation in the eviscerating room is essential. The air must be dust free and of sufficient entry velocity to provide a positive flow to minimize product contamination. This requires a system that ties in with the cooling and heating requirements of the plant, providing filtered cooled or heated air to flow away from ready-to-cook product areas at all times.

Chilling Area

To allow a continuous flow of product through the operation, the trend is now toward using inline-type chillers,[6] which lower the temperature of the carcasses to about 40° or 50° F in 3 to 4 hours. This eliminates the necessity of providing several hundred holding tanks and space in which to store the carcasses, plus the manpower required to push the tanks around. When inline chilling is used, the birds are sorted as to whether the end product will be whole, ready-to-cook, or further processed as they are removed from the eviscerating shackle. Since whole, ready-to-cook birds are trussed before chilling, a mechanized carcass sizer may be used to determine which are to be packed as whole, ready-to-cook birds and which are to be further processed. After the birds are discharged from the inline chillers, they are again sorted. The trussed, ready-to-cook birds are placed on the drip line, which takes them to the weighing and bagging operation while the carcasses to be further processed are placed in iced holding tanks and held for further processing. Storage space for holding these birds is provided in either the eviscerating and chilling area or in the cut-up section of the further processing area (fig. 8).

PACKAGING

Whole, ready-to-cook turkeys are bagged in plastic-film bags after chilling and before freezing. As birds are removed from the chillers, they are hung on an overhead drip line (for draining trapped water). The conveyor carries them to a table where the giblets and neck are inserted and the bird is weighed. The weight is marked on the bag before inserting the carcass. The air is then removed (from bag and bird) by vacuum, and the bag is sealed. The bagged bird is moved through a bag shrinking tunnel before being placed in a container holding one or more birds, depending on carcass size and marketing practice. Some plants place the birds in containers before freezing; others, not until the film-wrapped product emerges from the blast freezer. A two-piece container is required if birds are boxed before freezing (covers are not placed on the container until it emerges from the blast freezer).

Figure 7 shows an efficient equipment layout for the packaging area of the plant. The overhead drip conveyor line is equipped with mechanical release shackles that drop carcasses on a table-height belt conveyor on which grading and sorting (whole, ready-to-cook or for further processing) is done and the giblets are inserted. Figure 9 shows a bilevel conveyor system for boxing turkeys. Moveable boxing tables are placed between the bagged bird conveyor (1) and the boxed prod-

[6] Recent trends in the industry indicate that aging the turkey carcass overnight for tenderizing before bagging and freezing may not be necessary.

handling; (3) icing the boxes, if necessary; (4) closing boxes; (5) occasionally labeling; and (6) recording weights.

The shipping dock, as planned, accommodates five trucks. Space has been provided for making up mixed orders of various products (whole, ready-to-cook birds, chilled or frozen, and further processed items) for the same shipment.

Truck-bed heights vary from 46 to 56 inches when loaded and may be 6 to 8 inches higher when empty. A 48-inch dock height has proved satisfactory. Vertical clearance from ground to roof should be a minimum of 14 feet. A roof overhang of at least 4 feet should be provided for weather protection of the loading operation. Overhead doors may be installed at the dock openings if it is desirable to enclose the area.

The general office adjoins the order makeup area of the shipping department and is provided with windows, permitting management to observe operations.

OFFICES AND PERSONNEL FACILITIES

Pleasant comfortable surroundings contribute greatly toward worker productivity and improve quality of workmanship. In plants where pleasant surroundings have been provided, employee morale was observed to be much higher, resulting in a reduction of labor turnover. Providing a clean, well-lighted lunchroom; washrooms with adequate easily cleaned toilet facilities; well-equipped first-aid rooms; and an adequate parking area, conveniently located, reflect management's concern for employee welfare that is proving effective in reducing absenteeism.

In developing the basic plant layout (fig. 2), consideration was given to locating the employee facility and office area portion of the plant convenient to the work areas, yet keeping all areas for facilities auxiliary to processing operations grouped together in the same wing of the overall plant. This allows for surrounding the area with four masonry-type load bearing walls and covering it with a clear span of roof structure. All interior partitions may be of wood frame and dry wall paneling. Ceilings are lightweight, suspended-type panels. This allows for versatility in the layout of this area, which would greatly reduce costs of remodeling and renovation in the future. Figure 10 is a suggested layout of employee facilities and offices in this area. Space is shown for USDA inspector and grader offices. Air conditioning, both heating and cooling, for worker comfort is essential. Self-contained units suspended from the ceiling may be used.

Washrooms include lockers for employees' personal belongings, handwashing facilities, and toilet facilities. Regulations call for a minimum number of toilets and other requirements for poultry processing plants. Separate personal facilities have been provided for officeworkers. A washroom with shower and toilet is provided near the live bird receiving and slaughter areas for workers in these areas.

Adequate ventilation must be provided in all washrooms. This can be accomplished with built-in ceiling fans or screened window openings if the windows are located on exterior walls. Tinted concrete floors and ceramic tile wainscoting for walls are highly recommended for sanitation and pleasing appearance. All fixtures should be of the wall-hung type. Circular, foot-pedal controlled wash fountains require less space and are easy to keep clean. A few vanity-type lavatories with wall mirrors are suggested for the women's rest area. Good lighting, about 40 fc, is suggested. If electrical outlets are provided, they should be kept a safe distance from any water outlet and at least 12 inches above floor level. Both hot and cold water must be provided at washstands.

EXPANSION OF BASIC PLANT

In adding to the basic plant, as previously described, blast freezing, cold storage, and further processing areas can be added with minimum disruption to plant operations.

Blast Freezing Area

The first addition to the basic plant consists of the blast freezing compartment, refrigeration machinery room, the passageway alongside the blast freezer, and additional dry materials storage area on a second floor level above the freezer (figs. 2 and 3). The passageway area serves as a receiving dock for packaging materials and other plant supplies before adding the further processing additions.

Turkey products; whole, ready-to-cook birds; and further processed items must be hard frozen as rapidly as possible after chilling or processing to maintain quality and minimize spoilage hazards. This is best accomplished by directing a −30° to −50° F blast of air, with a velocity of 400 to 500 ft/min, over the product. To allow the cold air to circulate freely, the product is stacked on racks with space between containers. In the past, these racks were transported into the freezer and, after the freezing compartment was filled, the

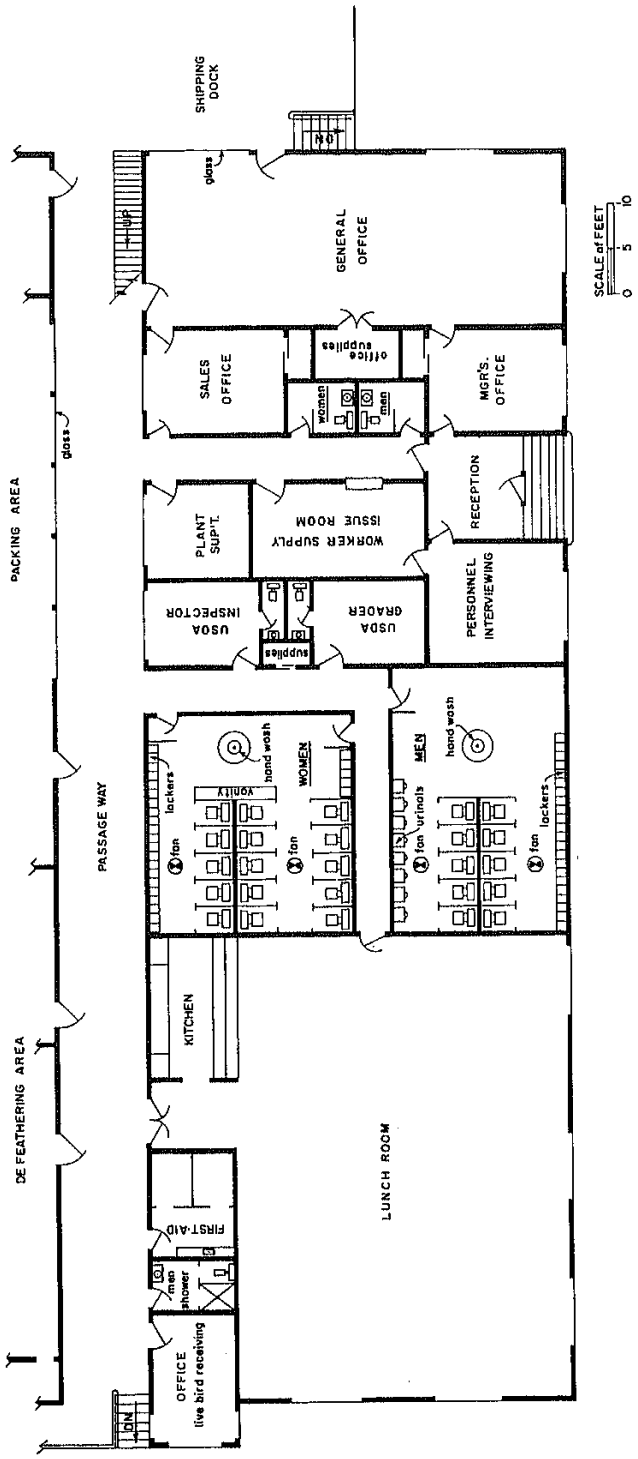

FIGURE 10.—Layout for office and personnel facilities area.

door was closed, and the refrigeration and fans were turned on. When freezing was completed, the system was turned off, the door was opened, and the entire batch of product was removed. In recent years, equipment manufacturers have developed mechanized conveyor systems that allow a continuous inline-type product flow through the fast freezing operation. One method used is illustrated in figure 11.

The product enters the freezer on a conveyor belt. When it reaches a position in line with the rack, it is mechanically pushed onto the rack shelf. When the shelf is full, the rack rises to the next shelf for loading. The loaded racks are then moved slowly across the top section of the freezer, lowered to the bottom section, then returned to the starting point where the frozen product is mechanically pushed onto the conveyor belt, which carries it to the sorting and palletizing area.

For an efficient operation, the blast freezer must be of sufficient capacity to freeze the product at the same daily production rate as the eviscerating and chilling operations. This prevents a bottleneck at this point in the production line, at times when the entire production is to be frozen.

The blast freezer, as planned in this report, should be large enough to hold an entire day's production with enough allowance for days of high production, that is, if extra birds are processed. The refrigerating equipment must be of sufficient tonnage to completely freeze these birds in a 24-hour period. This means that the work crew that handles the frozen product should start their daily shift 6 hours later than the work crew in the processing area. Figure 12 is a schematic sketch showing the 6-hour difference in starting times for the work crews.

Cold Storage Area

The cold storage addition consists of two rooms—the frozen storage area held at 0° F for long-term storage of frozen product and the smaller cold storage area held at 35° for short-term storage of chilled product. The 35° area also serves as an anteroom for entering the frozen storage area. This conserves on refrigeration for the frozen storage room and minimizes moisture buildup around door openings.

One of the most important structural features to consider when planning cold storage facilities is the use of moisture-impervious materials for walls, ceilings, and floors. If moisture penetrates these surfaces, the insulating efficiency decreases. Formation of ice crystals may cause heaving of floor slabs and general breakdown of other building materials. Doors for movement of product in and out are another problem area. If hinged wooden doors are used, they should be covered with metal and sealed to prevent moisture absorption and to protect the wood from damage by handling equipment. The ideal method of solving this problem in areas of heavy in and out traffic is the use of an air curtain. Under these conditions, however, air curtain fans tend to ice up if they are mounted inside the cold room; therefore, outside mounting is called for.

The cold storage area, as planned in this report, has a ceiling height of 25 feet, allowing pallet loads of product to be stacked four high (necessitating the use of pallet racks) and leaving a minimum of 3 feet clearance about the stack for air circulation. The use of pallet racks in storage areas eliminates carton damage caused by excessive weight at the bottom of the stack and toppled stacks. Pallet racks also permit first in, first out rotation of product. Special attention must be given to floor slab design when pallet racks are used, as the product load becomes concentrated at the four corners of the rack instead of being evenly distributed over the entire area the load covers.

The stacking layout (fig. 13) was planned with access aisles on both sides of the storage space to allow for first in, first out product movement. The aisles also allow better air circulation around the stored product.

Safety precaution measures required in this area include provisions for: (1) A safety exit door with positive inside latch release, (2) an alarm system that can be activated from inside the freezer, (3) sufficient light (10 to 20 fc) for clear vision for forklift operations, and (4) insulated clothing for all employees who work in the freezing areas.

Further Processing Area

With the addition of a further processing area (fig. 14), the plant becomes a facility equipped to efficiently perform all phases of processing operations used in preparing turkey for today's complex marketing process. Further processing adds greatly to the number of product forms, creating the necessity for providing a plant supplies and packaging materials receiving dock. The addition has also considered the need for additional space for USDA inspector's office in this area of the plant and, for further processed items, a quality control laboratory is suggested for quality surveillance.

The basic operations generally required in further processing turkeys are boning or cutting the birds into parts or both. Figure 14 shows a layout of the boning line and work stations for the preparation of specialty items patterned after the one developed and tested in earlier research *(3)*. Ample space for temporary holding of whole carcasses and cut-up parts has been provided. The parts and cuts can be packaged and shipped or frozen and then shipped; however, many plants no longer stop at this point in further processing. Therefore, space is provided for further proc-

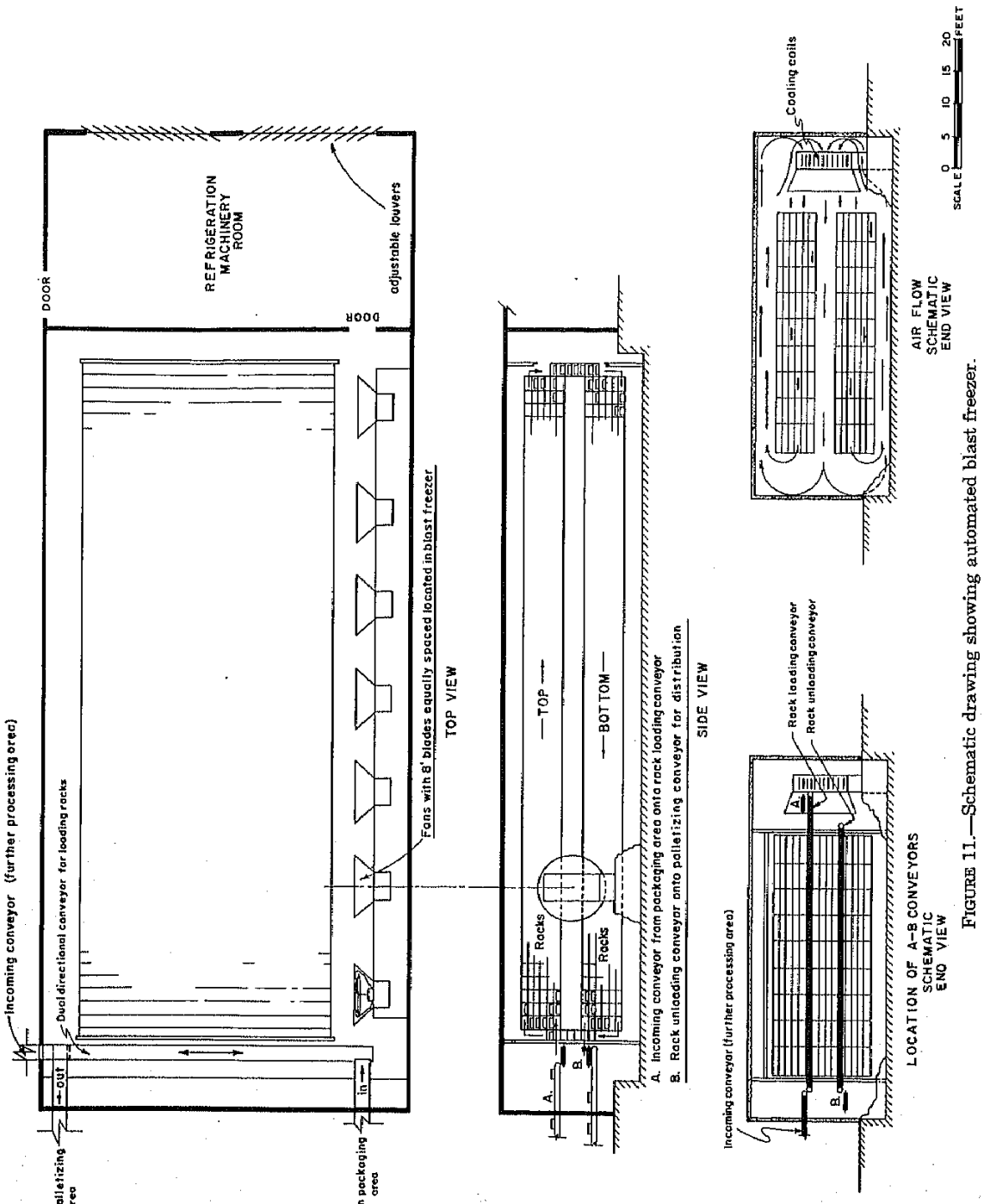

FIGURE 11.—Schematic drawing showing automated blast freezer.

essing into products, such as turkey rolls, steaks, and pot pies; cooked items, such as casseroles and heat-and-serve roasts; and others. The great variety of equipment that may become involved and variation in space requirements for such equipment are so great that no attempt has been made to suggest an overall layout.

Good lighting, a minimum of 40 fc, must be provided in this area. A smooth floor, pitched to trapped drains, is required. Water and steam outlets must be placed at convenient locations for cleanup and as required for hand washing by the further processing-room workers. Self-closing-type, foot-operated, hand-washing facilities are recommended. Above floor level, electrical outlets in convenient, safe locations should be provided for power tools and other electric-powered equipment.

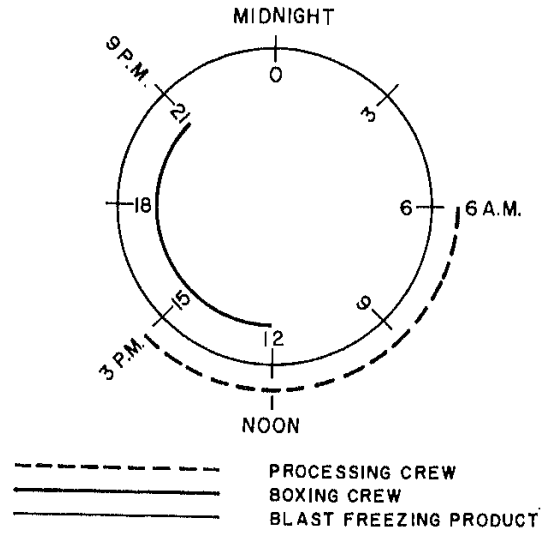

FIGURE 12.—Schematic illustration of time schedules for work crews when product is to be held in blast freezer for 24-hour periods.

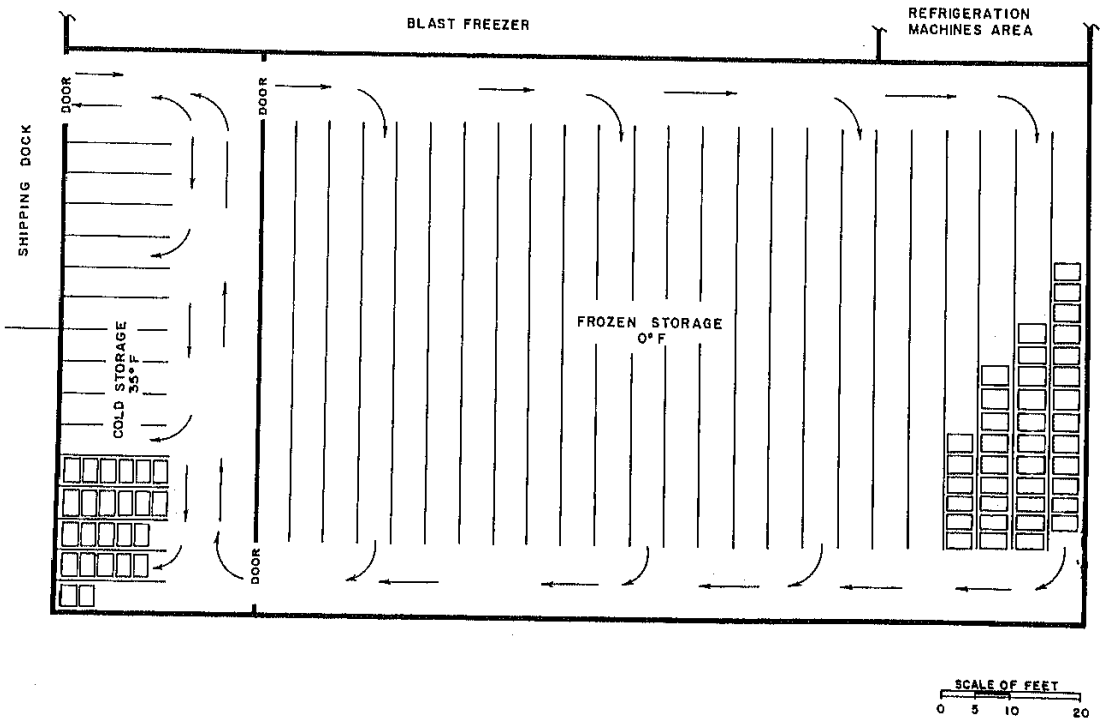

FIGURE 13.—Cold storage area layout.

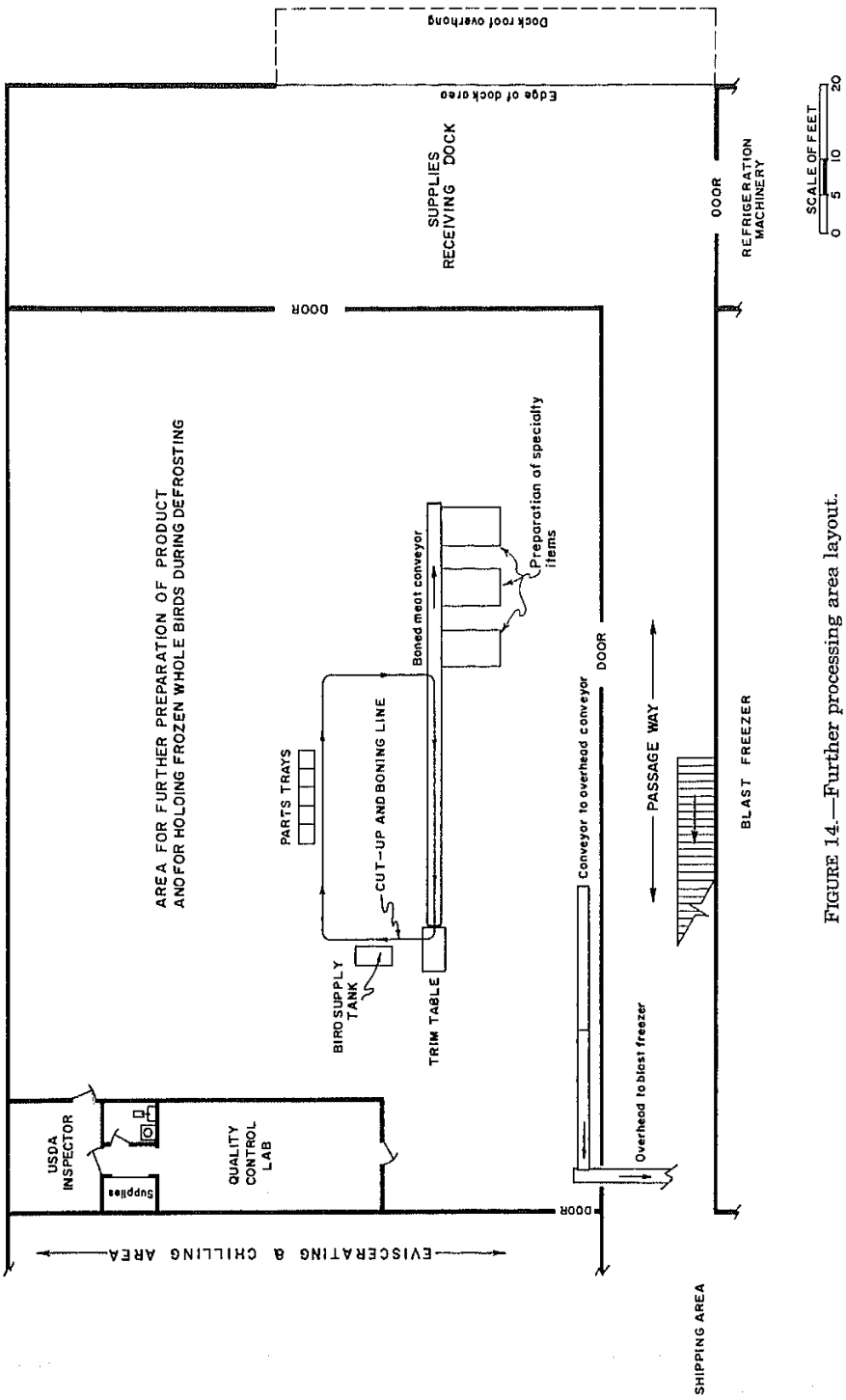

FIGURE 14.—Further processing area layout.

REFRIGERATION SYSTEM

An efficient refrigeration system is as important in the overall operation of processing turkeys as any other phase of the marketing operation. The moment the bird is slaughtered, body heat loss begins and continues slowly through defeathering and evisceration, then more rapidly during washing (inside and out) of the bird. The temperature of the water used for processing is low enough to accomplish some cooling, but additional refrigeration is required to provide prompt removal of the remaining body heat.

Factors that must be considered in selecting an adequate cooling system for the end product include product heat load, exterior and interior heat load of the room, and distribution of the chilling medium (water, air or both). Product heat load is dependent on the temperature of the birds when they enter the refrigeration medium. Room load is the heat transmitted through the walls, floor, ceiling, and doors. In addition, moisture-permeating vapor barriers increase the room heat load. Other heat loads refrigeration must contend with include heat entry and refrigeration losses during the opening and closing of refrigerator doors and heat given off by lights, electric motors, and workers in the room. The many variable factors involved in the complete refrigeration and icemaking system require the services of an experienced refrigeration engineering firm in planning and installing the equipment for the system.

Four different processes of cooling are involved in preparing turkeys for market. They are: (1) Chilling the eviscerated carcass with ice water, (2) blast freezing, (3) frozen storage, and (4) cold storage (for holding of chilled product prior to shipment). First, body heat must be quickly removed from the carcasses. Ideally, the body (ready-to-cook bird) temperature is reduced to 40° F within 3 to 4 hours after slaughter. One popular method of doing this involved inline-type chilling tanks that move the product through chilled or ice water. Icemaking machines, located over the ice storage bin, continuously feed ice to augers that supply the chillers from an overhead system. (Since chip ice has a tendency to stick together when stored, a worker or mechanical vibrator is required to break up the caked ice intermittently to provide the auger conveyor with a continuous supply.) Chillers are available which use chilled water, but no ice. Some chillers are jacketed, using direct expansion of refrigerant to cool the chill water.

Generally, the amount of ice needed for the first stage of chilling is 1 pound of ice per pound of turkey *(1)*. For a plant operating at 300,000 pounds of turkey per day this would amount to 150 tons per day of icemaking refrigeration capacity.

After chilling (if birds are to be held in frozen storage), the birds are subject to blast freezing that reduces the temperature of the whole turkey to 0° F or below. Air at a temperature of −40°, driven by high flow rate fans in the room described in figure 11, is most effective in rapid freezing of birds. Refrigeration of 160 tons is required to provide the freezing conditions necessary for the product load in a plant of this size. Associated with the refrigeration equipment are facilities for defrosting evaporator coils and automatic controls for timing the sequence of operations. Generally, engineered refrigeration systems of this magnitude must be performance tested over a period of time by a reliable equipment supplier after installation. Since the rate of travel of the conveyor system can be varied, a solid or a crust freeze can be obtained. Crust freezing of the product is sometimes used for the "fresh chilled" or "chill pack" market (not frozen). Immersion in propylene glycol refrigerant is occasionally used (in lieu of cold air blast) to accomplish crust freezing.

After the blast-freezing stage of refrigeration, the product is stored at 0° F or lower. This involves the rapid circulation of refrigerated air maintained at 0° or lower at all times. This can be accomplished by blowing cold air through perforated flexible plastic ducts, hung from the ceiling in the air space above the stacks of product.

The fourth type of refrigeration requires a cold storage room kept at 35° F. This cooler serves as an anteroom for the frozen storage area, which accomplishes three purposes: (1) Conserves refrigerated air from the frozen storage room, (2) prevents frost buildup at the freezer door openings, and (3) provides refrigerated space for "fresh chilled" or "chill pack" product. Refrigeration requirements of this area must be sufficient to balance heat pickup from the outside.

In designing the basic plant and additions, layout consideration was given to locating the refrigeration machinery room close to all areas where refrigeration is required, yet locating it on an outside wall to help dissipate heat buildup.

STORAGE OF PACKAGING MATERIALS

When the product requires only one type of container, such as when the entire output of the basic plant is confined to ready-to-cook, whole birds, the packaging materials storage area can be relatively small. However, all aspects of dry storage, including space requirements, inventory control,

materials handling, and capital investment, become complicated as plant volume increases and the end product is prepared in different forms.

In this layout, the packaging materials storage area is located on the second floor over the packaging and shipping areas and extends over the blast freezer when this addition is made. As shown in the basic layout (fig. 2), the dock where supplies are received is located at the end of the further processing addition after expansion has been completed. In the basic plant, the shipping dock is used for receiving supplies. A portable, inclined, power-driven conveyor is required for transporting materials to the second floor storage area. A stairway for workers is provided for access to the area.

Box makeup is carried on in the packaging materials storage area, and the made-up boxes are fed to the packaging operations below by gravity chute. Approximate location and number of floor openings for box chutes to the lower floor level should be planned in advance of actual construction.

Packaging materials manufacturers generally palletize large volume shipments for fast, easy handling with lift trucks; therefore, processing plants should provide for palletized handling of these items. A forklift truck equipped with a high-rise fork is an efficient method of elevating materials to the upper floor. They can then be moved into place with a pallet transporter that remains there for servicing the area.

Ample lighting must be provided for inventory of materials and for making up boxes with mechanized equipment. Electrical outlets must be provided for box makeup machines, portable power tools, space heaters, and coolers.

PLANT STRUCTURE

The physical appearance of a properly planned turkey-processing plant is attractive, with clean, well-balanced lines (fig. 15). The physical characteristics of the building used to house turkey processing operations differ from buildings in most industries, because it requires movement of a larger volume of perishable product, strict sanitary requirements for processing, and diversity of processing stages.

The main floor level should be raised above the natural grade to permit truck-bed height docks and provide good drainage. Four feet above grade was chosen because this is the average truck-bed height. Raising the floor to this level also provides space for access tunnels to drain lines, waterlines, and electrical conduits, while minimizing the hazards of damage by flooding.

Practically all materials used in the structure must be fireproof and impervious to moisture, which in general limits the structural materials to concrete and steel. Monolithic-type concrete floors are used in all plants. Floor maintenance is a problem, especially so in the eviscerating and further processing area. The large amount of water used in these areas, along with the fat from the bird being processed, creates a hazard for workers. Epoxy-type, acid-resisting floor coatings with fine, sharp aggregates added can be troweled onto the concrete slab to create a nonskid, acid-resisting surface. However, even after these precautions, the fatty acids and corrosive cleaning solutions generally used cause rapid deterioration of the surface under normal traffic conditions. This is an important factor in determining amortization rates for the building.

Hollow core masonry blocks of lightweight

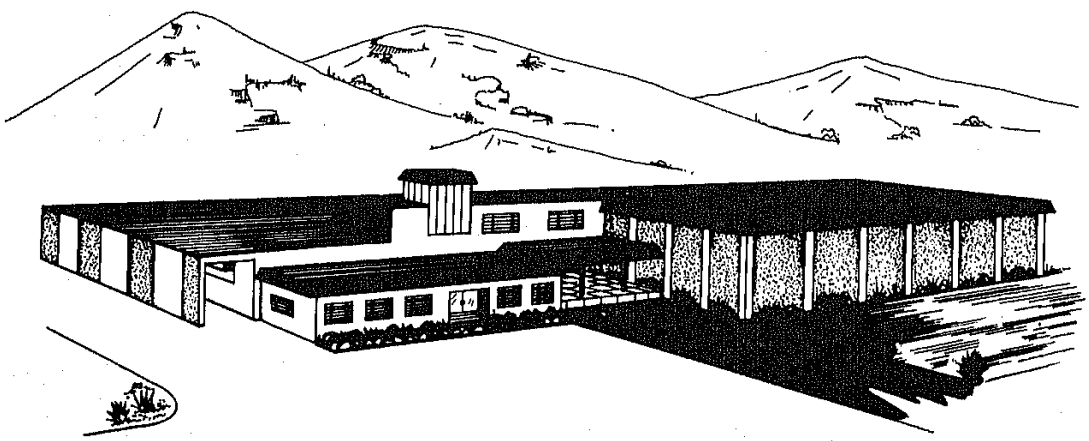

FIGURE 15.—Perspective sketch of turkey processing plant.

aggregate (cinder block) are ideal for processing plant wall construction. Steel reinforcing, both horizontal and vertical, may be installed where necessary to provide strength for stresses that may occur in this type of construction. If walls require moisture proofing, this can be accomplished with a coat of cement plaster or, in some cases, a brush coat of clear, moisture-proofing material. Hollow masonry blocks are also an ideal base for glazed tile, providing a surface that is impervious to moisture and has proved to be the wall surface most durable and easy to maintain.

Steel I-beams may be used for roof support members. The roof covering can he of steel sheets or prestressed, lightweight, concrete panels. The ideal system to use for roof construction is prestressed concrete beam and panel-type construction.

In most areas, ceilings are required to be of moisture-impervious surfaces. Plaster composed of portland cement and lightweight aggregate is ideal for this purpose when applied over metal lath. Metal divider bars may be exposed on the surface between panels to prevent cracking.

Recommended ceiling heights for different operation areas in the model plant are shown in figure 16. Overhead crawl space is provided over areas where much duct work and piping is required.

Soil, weather, and other environmental conditions vary greatly in different areas as well as local laws and building codes; all of which create the necessity of engaging a professional structural engineering firm acquainted with these factors for design calculations.

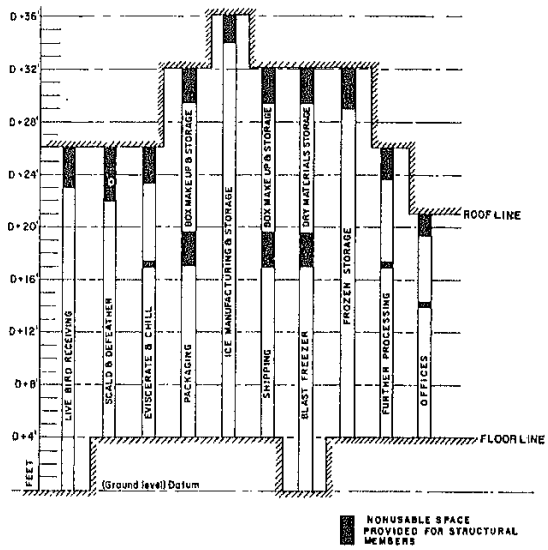

FIGURE 16.—Recommended ceiling heights and their relationship between areas and to overall plant height.

SITE LOCATION AND PLAN

Many factors must be considered when selecting the plant site for a turkey processing operation. Experience has proved that it is important to locate: (1) Near the area where live birds are grown since it is less costly to transport the finished product than the live birds, especially when weight loss (shrinkage) and mortality during extreme weather conditions are considered; (2) near a dependable and ample labor supply (much of the work can and is presently performed by women); (3) in a nonresidential area to avoid conflict with today's ecology-minded society that may object to this type of facility near their homes; and (4) in an area with adequate public utilities that are reasonably priced. The requirements for minimum and maximum quantities of electrical power, water, and gas must be established. Auxiliary fuel oil reserve may be desirable in case of low gas supply or to serve as fuel for a standby power source. Turkey processing requires large amounts of water, most of which must be of potable quality. This can be supplied either by public utility or plant-owned wells. In many locations, plant-owned wells are the most economical. If wells are used, the water quality must be certified by public health authorities.

Waste disposal is one of the big problems facing the industry today. Some plants use public-owned systems for disposal, others maintain their own. Oxidation ponds have proved to be effective and economical as a treatment in handling and treating sewage. Processing plants with operations that involve high biochemical oxygen demand (BOD) levels in the processing effluent have constructed their own treatment facilities. This construction is essential in locations not suited to lagooning or not having access to a public system. Solid waste (offal) handling is also a problem. A solution requires byproduct rendering facilities, either at the plant site for large operations or disposal through a commercial rendering plant where the volume is small. Community services (such as police and fire protection), taxes, transportation facilities, all-weather roads, and quality of neighboring businesses should all influence selection of the building site.

A 10-acre rectangular site was selected as a convenient size (land area greater than five times the plant area) for the plant site (fig. 17). If a rendering plant, sewage treatment, and oxidation pond are contemplated, the site would have to be much larger. If the plant is to be serviced by rail,

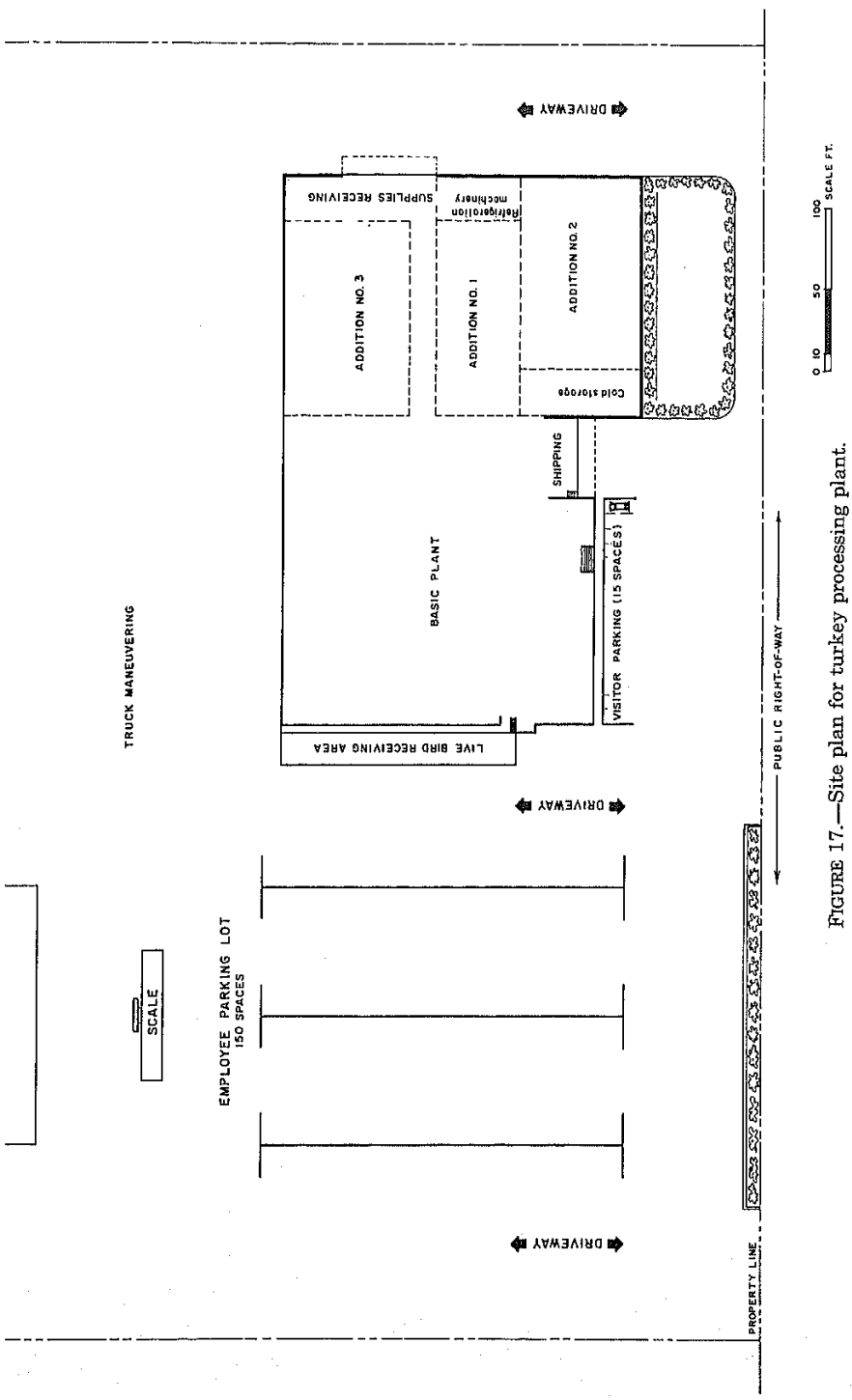

FIGURE 17.—Site plan for turkey processing plant.

a spur or rail siding should run parallel to the right side (as viewed in fig. 17) of the structure, allowing the use of the dock for receiving plant supplies and, if necessary, product loading to the railcars. Open land on two sides of the plant is recommended for future expansion.

Auto parking for 150 employees is conveniently located at the left of the plant, whereas parking for visitors and management is located in front of the plant, adjacent to the main entrance. Driveways of ample width for both autos and trucks provide access to the plant perimeter. A scale for weighing both empty and loaded trucks is located behind the plant and parking area. Nearby holding sheds provide weather protection for live birds. Space behind the plant is for truck parking, auxiliary sheds, additional shop space, or unused equipment storage.

ADDITIONAL REGULATORY REQUIREMENTS AND CONSIDERATIONS

In addition to the facilities, equipment, and operating requirements called for under the Poultry Products Inspection Act, poultry processing plants are now being required to meet the regulations under the Occupational Safety and Health Act as well as the restrictions placed on pollution of the environment by the Environmental Protection Agency. By citing a few problems and possible solutions, it is hoped that the poultry processor will be assisted in meeting the new requirements.

Noise created by most conventional defeathering equipment now in use generally exceeds the allowable noise level. Approaches that can be considered in dealing with this problem include: (1) Replacing defeathering equipment with equipment that muffles the noise; (2) reducing exposure time for workers involved by staggering assignments to areas of lower noise level; and (3) as a temporary expedient, furnishing workers with properly fitted ear muffs or earplugs. Another operation exceeding the current noise level is the removal of turkey lungs by vacuum. Temporary remedial action can be taken by enclosing the lung removal station with clear plastic sheets and providing workers with earplugs, that they *must* wear, or rotating them in exposure time with other workers. Other precautions that are suggested include: (1) Establishing an active employee safety committee, (2) following through on safety committee reports and recommendations, (3) investigating and documenting all accidents, (4) training employees in safety procedures and job hazards, (5) requiring the immediate treatment and protection of minor cuts against infection, (6) providing a medical attendant in first-aid room, and (7) protecting employees from obvious frequently overlooked hazards with adequate machine guards, stair railings, electrical wiring, switch insulation, floor drain covers, nonslip surfaces on walkways and at work stations, and lighting for stairways and halls.

In the area of pollution, most plants are confronted with an excessive BOD as well as a large volume of processing effluent. Research on methods and equipment for vacuum pickup of all poultry waste with only slight process change is well underway and should be available soon. In the meantime, reduction in water-use rates by more effective spray rinse through the use of proper nozzles (easily positioned and optimum droplet size) at the bird and hand washing stations can reduce the total amount of water used. Careful training of eviscerating and cleanup crews can reduce solids that are accidentally added to the effluent. Where local ordinances prohibit the scatter of feathers and dust from live bird operations, poultry coops or batteries should be cleaned out and washed after each trip, and the live bird receiving dock and adjoining area should be vacuumed continuously during live bird handling operations.

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